

screen device 200 as in FIG. 11C. The construct of device 200 is similar to that of the device of FIG. 11B but with the addition of a second thickness mode actuator 180' which sits atop touch plate 174. The two actuators and touch plate 174 are held in stacked relation by way of frame 178 which has an added inwardly extending top shoulder 178'. As such, touch plate 174 is sandwiched directly between the innermost output blocks 188a, 188b' of actuators 180, 180', respectively, while the outermost output blocks 188b, 188a' of actuators 180', respectively, buttress the frame members 178' and 178", respectively. This enclosed gasket arrangement keeps dust and debris out of the optical path within space 176. Here, the left side of the figure illustrates bottom actuator 180 in an active state and top actuator 180' in a passive state in which sensor plate 174 is caused to move towards LCD 172 in the direction of arrow 195. Conversely, the right side of the figure illustrates bottom actuator 180 in a passive state and top actuator 180' in an active state in which sensor plate 174 is caused to move away from LCD 172 in the direction of arrow 195'.

[0061] FIG. 11D illustrates another two phase touch sensor device 210 but with a pair of thickness mode strip actuators 180 oriented with the electrodes orthogonal to the touch sensor plate. Here, the two phase or bi-directional movement of touch plate 174 is in-plane as indicated by arrow 205. To enable such in-plane motion, the actuator 180 is positioned such that the plane of its EAP film is orthogonal to those of LCD 172 and touch plate 174. To maintain such a position, actuator 180 is held between the sidewall 202 of frame 178 and an inner frame member 206 upon which rests touch plate 174. While inner frame member 206 is affixed to the output block 188a of actuator 180, it and touch plate 174 are "floating" relative to outer frame 178 to allow for the in-plane or lateral motion. This construct provides a relatively compact, low-profile design as it eliminates the added clearance that would otherwise be necessary for two-phase out-of-plane motion by touch plate 174. The two actuators work in opposition for two-phase motion. The combined assembly of plate 174 and brackets 206 keep the actuator strips 180 in slight compression against the sidewall 202 of frame 178. When one actuator is active, it compresses or thins further while the other actuator expands due to the stored compressive force. This moves the plate assembly toward the active actuator. The plate moves in the opposite direction by deactivating the first actuator and activating the second actuator.

[0062] The subject transducers and actuators are also useful in fluid (i.e., liquid, gas, etc.) control and movement applications including valves and pump mechanisms. FIGS. 12A and 12B show a one-way poppet valve mechanism 220 employing thickness mode actuator 232. The actuator is seated within fluid chamber 234 having fluid inlet and outlet ports 236, 238, respectively. Actuator 232 is situated within chamber 234 such that its output structure 240 is aligned with outlet port 238. When actuator 232 is in a passive state, as shown in FIG. 12A, output structure 240 is buttressed against aperture 238' of the outlet port which defines the valve seat. As such, the valve has a normally closed configuration. As shown in FIG. 12B, the thickness mode operation of the actuator 232 when activated pulls output structure 240 away from valve seat 238' thereby allowing fluid within chamber 234 to exit through outlet port 238.

[0063] FIG. 12C illustrates a two-way poppet valve 250 having fluid chamber 254 with an inlet port 256 and two output ports 258a, 258b having respective apertures 258a',

258b'. An actuator mechanism 252 contained within the chamber includes two activatable portions 252a, 252b, each having an output structure 260a, 260b, respectively, aligned with output ports 258a, 258b, respectively. In the illustrated embodiment, actuator portion 252a is active while actuator portion 252b is inactive, thereby alternating fluid flow through the two outlet ports. However, both actuator portions may be activated in tandem, if desired. It can be appreciated that valve 250 may have any number of outlet port-actuator pairings with actuation function being accomplished with either a monolithic structure with a plurality of activatable portions, as illustrated, or a plurality of structurally discrete actuators. The individual actuators or actuator portions may be activated in tandem or independently, such that any combination of output flow is provided.

[0064] The subject actuators are also suitable for use with diaphragm type pumps. One such diaphragm pump 270 is shown in FIGS. 13A and 13B in which the fluid chamber 274 has inlet and outlet ports 276, 278, respectively, having check valves mechanisms to control fluid flow therethrough. The output structure 280 of thickness mode actuator 272 is affixed to the underside of a diaphragm 282 that extends between the sidewalls and across the upper end of chamber 274. The diaphragm is made of a material stiff enough to not flex or stretch under compression pressure, e.g., fiber reinforced rubbers, stiff elastomers, filled silicone, a thin metal membrane, etc. Activating and deactivating actuator 272 moves diaphragm 282 away and towards, respectively, the inlet and outlet ports. With the positive pressure created in chamber 274 when diaphragm 274 is moved towards the ports, as illustrated in FIG. 13A, outlet check valve 278 is caused to open allow fluid to be exhausted from the chamber. Conversely, with the negative pressure created in chamber 274 when diaphragm 274 is moved away from the ports, as illustrated in FIG. 13B, inlet check valve 278 is caused to open, creating fluid intake to the chamber.

[0065] FIGS. 14A and 14B illustrate another diaphragm-type pump employing thickness mode a multi-actuator mechanism 276. The actuator has three activatable portions 276a-c (but may have more or fewer portions), with the outer two portions 276a, 276c being aligned relative to inlet-outlet ports 274a, 274b, respectively, of fluid chamber 292. Diaphragm 298 is coupled at its underside to the respective output structures 300a-c of the actuator portions. To exhaust fluid from chamber 292, one or both ports 294a, 294b are opened, as illustrated in FIG. 14A, by activating outer actuators 296a, 296c. Conversely, deactivating the outer actuators while activating the center actuator 296b, as illustrated in FIG. 14B, closes both valve ports while also priming the pump for the next exhaust stroke. Diaphragm sheet 298 may employ multiple materials so as to facilitate the poppet valve sealing, for example, the membrane could be made of a metal foil with rubber coating over the valve area.

[0066] The multi-phase linear actuator mechanisms of the present invention are also highly suitable for use with peristaltic pumps. Such as pump 310 of FIGS. 15A and 15B. Pump 310 comprises a chamber or conduit (which may have any suitable cross-sectional shape, e.g., cylindrical, rectangular, square, etc.) having a base 312a and a top portion or cover 312b. Thickness mode actuator mechanism 318, here having four activatable portions illustrated, is offset from base 312a by output or mounting structures 314a. The opposing output structures 314b are coupled to the underside of diaphragm 316. The spacing provided by the offset of the